The Effects of Quinoa and Chickpeas Flours on the Physical, Chemical, Functional and Sensorial properties of Tarhana Soup

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Abstract

Tarhana soup is a traditional fermented food made of mainly a mixture of cereal and yoghurt. It is like products have been enriched or replaced with cereal and pseudocereal. This research determined the effect of substituting wheat flour 72% (WF) with different ratios of chickpeas flour(CHF) ,white quinoa flour (WQF) and mixed- (CHF & WQF) on functional, rheological and sensorial properties of tarhana treatments. High CHF and WQF substitute (100%) in tarhana production showed higher contents of protein, lipids, ash, crude fibers, total phenolic compounds, phytic acid and antioxidant capacity by free radical 1, 1-diphenyl-2-picrylhydrazyl (DPPH) in comparison to wheat flour (72%). pH values of tarhana treatments were decreased from 5.12-6.01to 4.85-5.75 after 72 hrs. of fermentation. Fermentation loss values of tarhana treatments ranged between 9.48% and 12.23%. Substitution of WF in tarhana formulations with CHF and WQF reduced the yellowness of tarhana samples. The addition of different CHF and WQF significantly ($p \leq 0.05$) improved the water and oil absorption capacity of tarhana treatments. Also, partial substitution of WF with CHF, WQF and mixed-cereal in tarhana recipe has significantly ($p \leq 0.05$) increased the foaming capacity and stability of the final product. The highest values of sensory parameters were observed in tarhana soups prepared with 100 % CHF, 50% WQF and control sample gave the highest scores for consistency and overall acceptability. According to the results of this research, it is possible to partially or completely substitute wheat flour with CHF, WQF in tarhana soup production in an attempt to have a product combining the nutritional value of legumes, pseudo-cereals and the health benefits of lactic acid bacteria.

Keywords: Tarhana; Quinoa flour; Chickpeas Flour; Sensorial properties and Rheology; Functional properties and Lactic acid bacteria

Introduction

Fermented foods were an essential element of many people's diets around the world. Most people in Turkey consume a lot of Tarhana, which is a fermented product. Tarhana was made by fermenting wheat flour, yoghurt, yeast, and a variety of vegetables and spices (tomatoes, red peppers, onions, mint, salt, and so on) for a few days before drying and milling[1]. Tarhana is a traditional fermented meal comprised primarily of a cereal-yoghurt blend. It appears that cereal and pseudo-cereal have been added to or replaced in the products [2].In addition, tarhana-like products have been discovered in a number of countries."Kishk" in Egypt, Syria, and Jordan, "trahana" in Greece, "turkhana" in Bulgaria, "kushuk" in Iraq and Iran, "tahonya/talkuna" in Hungary and Finland, and "tarana" in Serbia are the terms used [3] .Tarhana is a high-nutrient food that is high in proteins, vitamins (B1 and B2), and minerals (calcium, iron, sodium, potassium, magnesium, zinc, and copper) [4].

Tarhana, which is especially beneficial for children and babies, also helps to build and strengthen bones. The benefits of the tarhana are due to the lycopene contained in its body, which protects it from a variety of ailments. As a result, tarhana is commonly used in human diets, according to Banolu and Banolu [5] and Üçok *et al*. [6].Tarhana has an acidic, sour flavor and a pungent scent, and it can be used to make soup by diluting it. It's packed with protein, vitamins, and minerals. As a result, it is commonly utilized in the nutrition of youngsters and the elderly [7].To improve the characteristics of traditional tarhana, it can be changed and prepared with other substances. It was made with lentils and chickpeas [8], several research have been done using tef flour to make gluten-free tarhana: corn flour: potato starch [9], corn flour [10], taro flour and Jerusalem artichoke flour [11], quinoa: rice flour combinations [2], rice flour [12], and whole wheat & chickpea flours [13].

Quinoa (*Chenopodium quinoa*) is considered a super food since it is a good source of complete protein, unsaturated fatty acids, minerals, vitamins, fiber, and antioxidants. It is a pseudo-cereal that has been cultivated in the Andean region of South America for thousands of years and belongs to the

Chenopodiaceae family [14]. In addition, quinoa is known more for the quality of its protein as it contains all essential amino acids (EEAs) in its structure, which correspond to the daily recommended intake of amino acids reported by the Food and Agriculture Organization (FAO) of the United Nations and the World Health Organization (WHO). Based on all these reasons, quinoa is considered to be an important nutrient, especially for infants and children [15].

Chickpea (*Cicer arietinum L.*) is drawing attention recently, and it is included in some food preparations due to its high protein digestibility and rich protein, carbohydrate, B vitamin and mineral content [16]. Amongst legumes, chickpea is a good source of protein, dietary fiber, some vitamins (thiamine, niacin, and ascorbic acid), minerals (Ca, Fe, K, Mg, and P), unsaturated fatty acids (linoleic, oleic) and of the essential amino acids which are deficient in wheat flour [17]. Further, complex formation between phytates and proteins affects protein digestibility and bioavailability, thus restricting legumes from imparting nutritional benefits to their maximum potential. There are many evidences stating that the nutritional benefit of legumes can be improved by treatments like fermentation before their incorporation into legume-supplemented products [18]. Their biological activity has been well studied, and it has been demonstrated that they are antiviral, antifungal, mutagenic, and particularly anticancer (breast and prostate) [19]. This research aimed to determine the functional, rheological and sensorial properties of tarhana prepared with different substitution ratios of quinoa and chickpeas flours

Materials and Methods

1. Materials

Commercial wheat flour (72% extraction), chickpeas flour, white quinoa flour, full-fat yoghurt ((Al-Marai) made from cow milk), tomato paste (Heinz, 21% TUS), chopped onions, paprika, salt and active dry yeast (DCL instant yeast); used in tarhana preparation were purchased from local market in Cairo, Egypt.

2. Methods

2.1. Production of tarhana

According to Bilgicli *et al*., [20] a control tarhana sample was produced. 400.0 g wheat flour, 160.0 g yoghurt, 40.0 g tomato paste, 20.0 g chopped onions, 8.0 g paprika, 4.0 g table salt, and active dry yeast (10.0 g). All of the ingredients were blended in a stand mixer (Moulinex, France) for 5 minutes on high speed to produce a dough, which was then placed in glass containers and fermented at 30°C for 72 hours. The mixture was manually blended every 12 hours throughout fermentation. During fermentation, the PH of tarhana samples was measured at 0, 24, 48, and 72 hours. After fermentation, samples were formed into small pieces and dried in an air convection oven at 55 °C for 48 hours (Binder, Germany). Dried samples were ground and sieved using a 1 mm opening sieve and stored in polyethylene bags in a dry place until analysis.

Six different formulas were used for the preparation of tarhana treatments Table (1) by substituting wheat flour (72%) with different ratios of chickpeas flour, white quinoa flour and mixed flour

Table (1): Different substitution ratios of wheat flour and replacer flours used in tarhana production

*Flour	Treatments (%)					
	1	**2**	**3**	**4**	**5**	**6**
WF (72%)	100	-	-	50	50	50
WQF	-	100	-	-	50	25
CHF	-	-	100	50	-	25

***WF:** Wheat flour (72%), **CHF:** chickpeas flour and **WQF:** white quinoa flour

2.2. Proximate Chemical composition of dried and ground tarhana treatments

2.2.1. Dried and ground tarhana samples were analyzed for Moisture, Protein, Lipids, Ash and Crude fibres contents by Official Methods [21] and carbohydrate was calculated by difference.

2.2.2. **Total phenolic** compounds, as gallic acid were measured in powder tarhana samples and replacer flours, according to Jayaprakasha *et al*. [22].

2.2.3. **Phytic acid** content was measured by a colorimetric method according to Haug and Lantzsch [23]**.** The absorbance of the solution was measured at 519 nm wavelength against distilled water. A standard curve was prepared using sodium phytate solution. Determination was conducted in triplicate.

2.3. DPPH radical scavenging activity:

The effect of extracts on the free radical 1, 1-diphenyl-2-picrylhydrazyl (DPPH) was calculated using the procedure described by Aboelsoued *et al*. [24] the absorbance at 517nm was measured using a spectrophotometer. Ethanol was utilised as a control in place of the sample. The DPPH scavenging capacity was calculated using the following equation:

$$\text{Scavenging activity (\%)} = \frac{Ac - As}{Ac} \times 100$$

Where Ac and As are the absorbance's at 517nm of the control and treatments, respectively.

2.4. Physical analysis

2.4.1. PH of tarhana dough was measured during fermentation using a digital pH meter (HANNA, HI 2211), after mixing 5 g sample with 100 ml distilled water [25]**.**

2.4.2. Fermentation loss percent of tarhana treatments were determined according to Bilgicli[26] and calculated using**:**

$$\text{Fermentation loss (\%)} = 100 \times \frac{(a \times b) - (c \times d)}{(a \times b)}$$

Where: a = weight of tarhana dough before fermentation (g), b = dry matter ratio of tarhana dough before fermentation (%), c = total weight of ground dry tarhana (g) and d = dry matter ratio of ground dry tarhana (%).

2.4.3. **Color measurements**

The color of tarhana powder samples was measured using a Spectrophotometer (MOM, 100 D, and Hungary). For each treatment, three replicates were carried out. The color attributes that correlate with Hue angle, Chroma, and Total color index are represented in a three-dimensional color space, x, y, and z, known as CIELAB, from which the hunter color parameters L*, a*, and b*, Hue angle, Chroma, and Total color index were calculated using this equations:

$$L* = 116\ (Y/100)^{1/3} - 16$$

$$a* = 500\ (X/98.07)^{\frac{1}{3}} - (Y/100)^{1/3}$$

$$b* = 200(Y/100)^{1/3} - (Z/118.22)^{1/3}$$

$$Chroma = \sqrt{a*^2 + b*^2}$$

$$\Delta E = \sqrt{\Delta a*^2 + \Delta b*^2 + \Delta L*^2}$$

Where L* is the measurement of luminosity ranged between black (0) and white (100), parameter a* takes positive values for reddish colors and negative values for the greenish ones, whereas b* takes positive values for yellowish colors and negative values for the bluish ones [27].

2.5. Determination of functional properties

2.5.1. **Water/Oil absorption capacity** (WAC & OAC) of treatments were determined according to Hayta *et al.* [28], in which 5 grams of tarhana powder were mixed with 25 mL distilled water/sunflower oil, and the mixture was mixed and centrifuged (4000 rpm for 20 min).The water or oil absorption capacity of 1 g flour was calculated as a percentage of water or oil absorbed.

2.5.2. **Foaming capacity (FC)** of tarhana treatments were measured according to Hayta *et al.* [28], using 10 grams of tarhana powder mixed with 25 ml distilled water, stirred, and centrifuged (4000 rpm for 20 min).The resulting supernatant was whipped at high speed for 2 minutes, and the volume of the foam was measured after 10 seconds (Moulinex blender, France.The volume of gas integrated per mL of solution was used to calculate foaming capacity.As time progressed, foam stability (FS) was measured until half of the original foam volume had disappeared. Foaming capacity (%) = A – B / B X 100

Where A = volume after whipping (mL) and B = volume before whipping

% Foam stability = foam volume after time (t) / Initial foam volume X 100

2.5.3. **Emulsification activity (EA)** was determined according to Hayta *et al*. [28], 10 grams of tarhana powder mixed with 25 ml distilled water and stirred for 20 min. and then centrifuged (4000 rpm for 20 min). The supernatants were then combined with equal amounts of sunflower oil and homogenised in a waring mixer.A measuring cylinder was used to calculate the emulsified layer.The ratio of the height of the emulsified layer to the total height of the mixture was used to calculate the emulsification activity (percent).

2.5.4. **Sensory properties**

Sensory properties of tarhana soup were determined according to Hayta *et al*. [28], by mixing 10 grams of tarhana powder with 100 ml of vegetable broth and cooking for 12 minutes over medium heat. The samples were served in disposable cups at 50ºc and judged by ten panelists. Taste, color, flavor, consistency, sourness, and general acceptability of tarhana soup samples were assessed on a 9-point scale, with 1 indicating a strong dislike, 5 indicating neither like nor dislike, and 9 indicating a strong liking.

2.6. Statistical analysis

The data obtained from the present study were statistically subjected to analysis of variance (ANOVA) according to Snedecor and Cochran [29] by the computerized program SPSS software, version “20” for Windows. The least significant difference (LSD) value was used to determine the significant difference between means. Data were represented as Mean ± SD.

Values were considered significant at $p \leq 0.05$, otherwise were considered non-significant.

Results and discussion

Proximate Chemical composition of dried and ground tarhana treatments

The chemical properties of the tarhana treatments are presented in Table (2). The moisture content of T1, T4, T5, T2 and T3 was found to be significantly ($p \leq 0.05$) respectively higher than the control treatment (6.87±.04). Regarding the protein content, the replacing of wheat flour with chickpea flour and quinoa flour at different levels tend to increase the protein content in tarhana treatments and the peak value of protein content was observed in T2 , T3 , T1,T4 and T5 . This is an expected finding, the protein content of the tarhana is increased when a legume flour is substituted with wheat flour. Because legume flours have higher protein content compared to wheat flour. Besides, mixing of the legumes and cereals ensure a better combination that provides maximum benefit from the essential amino acids [30]. Paraske *et al*. [31] stated that legumes can be successfully incorporated into the baked products for enrichment in regard to protein composition. Erkan *et al*. [32] stated that variations in the protein content in different tarhana samples depended on the amount and type of yoghurt and properties of cereal or legume flours. Crude protein, ash and crude fat contents in quinoa are generally higher than in common cereals such as wheat [33]. In a study of Alvarez-Jubete *et al*. [34] quinoa seeds was reported to contain 14.5% protein, 5.2% fat, 64.2% total starch, 14.2% dietary fiber and 2.7% ash

High-fat content was found significantly ($p \leq 0.05$) in tarhana treatments in T1 (100%WQF) and T2 (100% CHF) (5.68±.10 and 4.57±.10) respectively when compared the control treatment (1.28±.10). High WQF addition level (100%) and CHF addition level (100%) to tarhana formulation increased the ash content of the tarhana samples when compared with the other WQF and CHF addition levels. The lowest ash values were determined in the tarhana samples made with 50% CHF. High Crude fibers were found significantly (*p*≤0.05) in tarhana treatments in T1 (100% WQF) and T4 (50% WF + 50% WQF) respectively when compared to control treatment. Carbohydrate content was decreased due to the increase in the amount of WQF and CHF flours in the tarhana samples when compared with the control. Bilgiçli [26] found that the ash, protein and fat content of gluten-free tarhana samples, produced from 60% buckwheat flour + 20% corn starch + 20% rice flour, were 2.29%, 15.0% and 7.2%, respectively.

Table (2): Proximate Chemical composition of dried and ground tarhana treatments

Treatments	Major chemical constituent (%)					
	Moisture	**protein**	**Fats**	**Ash**	**Crude fibers**	**carbohydrates**
Control	6.87±.04[a]	11.46±.38[a]	1.28±.10[a]	.43±.06[a]	3.42±.10[c]	76.54±.36[f]
T1	11.91±.05[f]	13.75±.10[c]	5.68±.10[f]	4.87±.10[f]	7.34±23[e]	56.45±.14[a]
T2	8.31±.05[c]	24.71±.10[e]	4.57±.10[e]	2.68±.10[e]	1.74±.10[a]	57.99±05[b]
T3	7.59±.08[b]	18.33±15[d]	2.34±.10[c]	1.10±.09[b]	2.33±.25[b]	68.30±.25[d]
T4	10.36±.10[e]	12.57±.10[b]	2.76±.10[d]	2.30±.18[d]	4.28±.10[d]	67.73±.39[c]
T5	9.46±.10[d]	11.36±.10[a]	2.34±.23[c]	1.83±.09[c]	3.59±.10[c]	71.42±.32[e]

Control: Wheat flour (WF) (72%), T1: white quinoa flour (WQF) (100%), T2: chickpeas flour (CHF) (100%), T3: 50% WF + 50% CHF, T4: 50% WF + 50% WQF and T5: 50% WF +25% CHF +25% WQF. Data are presented as means ± SDM (n=3). a, b, c, d, e and f: Means with different letters among treatments in the same column are significantly different (*p*≤0.05).

Total phenolic content, Phytic acid and Antioxidant capacity DPPH (%) determination of tarhana treatments

The total phenolic content of the treatments was determined in Table (3). Results were found between 828.82-1325.20 µg GAE/g .According to the results, the highest total phenolic content was found in the (T1 100%WQF and T2 100% CHF) (1325.20 µg GAE/g ±1.00 and1177.29 µg GAE/g ±1.00) respectively when compared the control treatment (828.82 µg GAE/g ±3.05). It was found that the increasing replacer flours in the tarhana formulation increased the phenolic content. The total phenolic content of the insoluble-bound fraction of the grain might be altered by the various food processing methods of grain-based food products, such as kneading, baking, fermenting, drying, etc [35]. It was suggested that the addition of quinoa flour increased the antioxidant capacity of the cookies. Quinoa has stronger antioxidant activity in comparison with wheat [36].

When the phytic acid was examined, the highest phytic acid content was determined with T2 (100% CHF) (1,556.09 mg/100 g) followed by T1 (100%WQF) (905.10 mg/100 g), respectively. The lowest content of phytic acid was determined with 100% wheat flour (control) (153.30 mg/100 g). The quinoa flour added tarhana samples gave lower phytic acid values than the other replacer flours. It was seen that the increasing usage level of replacer flours also increased the phytic acid content of tarhan in Table (3). This situation could be explained by the higher phytic acid content of replacer flours than wheat flour. Despite their disadvantages (ant nutritional factor), phytic acid is useful for health benefits. Phytic acid supports colon health by lowering blood sugar, and decreasing digestion of starch [37]. Phytic acid is a well-known antioxidant of natural origin. Iron binding increases ant oxidative activity by reducing lipid peroxidation and free radical formation [38]. Research by Shahzadi *et al*. [39] confirms that mixing 10% chickpea flour with wheat flour reduces phytic acid content from 0.81 to 0.54%. Additionally, the heating process and degreasing of flour lead to a reduction in phytic acid content in chickpea flour [40].

Antioxidant capacity1, 1-diphenyl-2-picrylhydrazyl (DPPH) (%)

Antioxidant capacities of tarhana treatments were also investigated using the DPPH analysis method. Results showed between 66.78-87.05% of DPPH scavenging activity Table (3). When antioxidant capacities of replacer flours were examined, increasing levels of quinoa and chickpeas flours in tarhana formulation resulted in significantly ($p \leq 0.05$) increased antioxidant capacity values. Replacer flours gave higher antioxidant capacities (DPPH) than wheat flour, so higher antioxidant capacity values of tarhana treatments (100 % WQF and 100 % CHF) (87.05 %±0.44 and75.92%±1.03) respectively. When the phenolic matter content and antioxidant activities of legumes were examined, it was seen that flavonoids were dominant and the grains exhibited antioxidant activity due to phenolic component contents **(41)**.

Alvarez-Jubete *et al.*[34]investigated the pseudocereals quinoa and buckwheat as potentially healthy ingredients for improving the nutritional quality of gluten-free bread and found the antioxidant capacities of these bread samples as buckwheat > wheat > quinoa. Saharan *et al.* (42) found a positive correlation between total phenolic and flavonoid content with antioxidant activity. The role of α-amylase, xylanase and β-glucosidase enzymes in the release of polyphenols and antioxidants during solid state fermentation of cereals was justified by a linear correlation obtained between total phenolic and flavonoid contents with enzyme activities. Chickpea has antioxidant properties due to the presence of peptides and polyphenolic compounds. Several peptides with antioxidant potential have been identified from chickpea protein hydrolysates and considerable amounts of phenolic compounds and anthocyanins with antioxidant activity have also been detected in chickpea **(43).**

Table (3): Total phenolic content, Phytic acid and Antioxidant capacity DPPH (%) determination of tarhana treatments

Treatments	Total phenolic (µg GAE/g)	Phytic acid (mg/100g)	DPPH (%)
Control	828.82±3.05[a]	183.64±2.00[a]	66.78±1.01[a]
T1	1325.20±1.00[f]	1055.75±2.00[e]	87.05±0.44[e]
T2	1177.29±1.00[e]	1236.75±1.52[f]	75.92±1.03[d]
T3	1095.12±1.52[c]	985.80±1.00[d]	72.14±2.38[bc]
T4	1125.64±1.00[d]	942.8±1.00[c]	73.85±0.82[cd]
T5	1084.55±2.20[b]	837.04±2.00[b]	70.97±1.98[b]

Control: Wheat flour (WF) (72%), T1: white quinoa flour (WQF) (100%), T2: chickpeas flour (CHF) (100%), T3: 50% WF + 50% CHF, T4: 50% WF + 50% WQF and T5: 50% WF +25% CHF +25% WQF. Data are presented as means ± SDM (n=3). a, b, c, d, e and f:

Means with different letters among treatments in the same column are significantly different ($p \le 0.05$).

Physical properties of Tarhana treatments

PH values of tarhana treatments:

It is important to determine pH values of food products for determining their suitability for consumers, also relatively low pH inhibits pathogens and spoilage microorganisms which increase the shelf-life of food products [44]. Changes in pH values of different tarhana treatments Table (4) were observed during fermentation period at 0, 24, 48 & 72 hrs., long fermentation time significantly ($p \le 0.05$) decreased the pH values of tarhana treatments from 5.12-6.01to 4.85-5.75.

Treatments of 100% CHF and 100 %WQF showed the highest pH values of 6.01- 5.75 and 5.91±.01- 5.60±.006 respectively. Results were described by Kohajdova *et al*. [45] in instant chickpea flour (6.23 ± 0.01) and is closed to our results. Moreover, in the presence of quinoa higher pH values were observed indicating the buffering capacity of the pseudocereal as suggested by other authors [46]. While control treatment achieved the lowest pH values of 4.85. pH values were affected by fermentation time as they decreased by time and that reduction of pH was due to the production of organic acids during fermentation by yeast and lactic acid bacteria of yoghurt and that agrees with Ibanoglu [47] , Erbas *et al*.[48] and Gabrial *et al*.[49] **.**The pH of all the treatments decreased dramatically at the initial stages of the fermentation.

Table (4): Changes in pH values of tarhana treatments during fermentation (72hrs.)

Treatments	pH at the Fermentation time (hrs)			
	Zero	**24**	**48**	**72**
Control	5.12±.005Da	5.00±.00^{Ca}	4.92±.00^{Ba}	4.85±.00^{Aa}
T1	5.91±.01^{Df}	5.82±.00^{Ce}	5.74±.006^{Be}	5.60±.006^{Ae}
T2	6.01±.006^{Df}	5.91±.00^{Cf}	5.86±.00^{Bf}	5.75±.00^{Af}
T3	5.69±.006^{Dc}	5.61±.00^{Cc}	5.54±.006^{Bc}	5.39±.006^{Ac}
T4	5.71±.006^{Dd}	5.62±.006^{Cd}	5.56±.00^{Bd}	5.48±.006^{Ad}
T5	5.60±.00^{Db}	5.51±.00^{Cb}	5.44±.00^{Bb}	5.37±.00^{Ab}

Data are presented as means ± SDM (n=3). A, B, C and D: Means with different letters among treatments in the same row are significantly different ($p \leq 0.05$): a, b, c, d, e and f: Means with different letters among treatments in the same column are significantly different (P 0.05).Control: Wheat flour (WF) (72%), T1: white quinoa flour (WQF) (100%), T2: chickpeas flour (CHF) (100%), T3: 50% WF + 50% CHF, T4: 50% WF + 50% WQF and T5: 50% WF +25% CHF +25% WQF

Rheological Properties of tarhana soup:

Fermentation loss values

Fermentation loss values of tarhana treatments presented in Fig. (1), ranged between 9.48% and 12.23%. The highest values of fermentation loss were recorded for tarhana treatments formulated with high substitution ratios of quinoa flour and chickpeas flour. Fermentation loss values were 12.23, 10.42, 10.26, 9.85, 9.77 and 9.48% for (100%WQF), 50% WF + 50% WQF, (100% CHF), 50% WF + 50% CHF and 50% WF +25% CHF +25% WQF treatments respectively, In comparison to 9.48% for control sample. These results show that WQF and CHF addition levels influenced fermentation loss values of tarhana samples. Optimal fermentation is essential in the functional and sensory properties of tarhana for consumer acceptability. Over fermentation causes not only a decrease in functionality, but also a loss in the dry matter up to 25% [(50)] .Long fermentation process (72 hrs) during tarhana preparation by lactic acid bacteria and baker's yeast was responsible for fermentation losses [(26)].

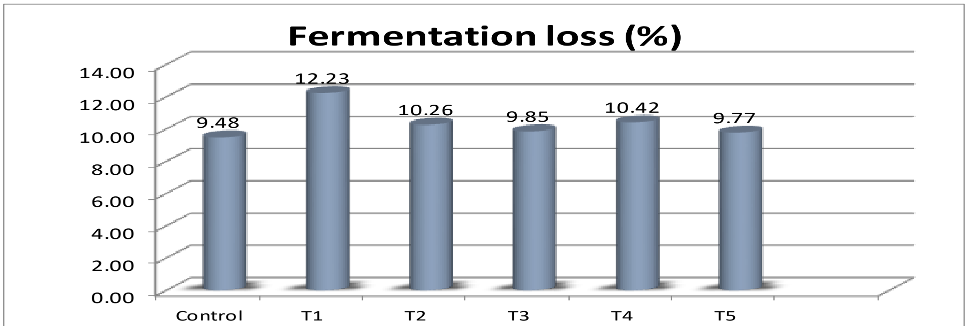

Fig. (1): Fermentation loss values of tarhana treatments

Control: Wheat flour (WF) (72%), T1: white quinoa flour (WQF) (100%), T2: chickpeas flour (CHF) (100%), T3: 50% WF + 50% CHF, T4: 50% WF + 50% WQF and T5: 50% WF +25% CHF +25% WQF

Color values of tarhana powder

Color is an important quality factor for the acceptance of tarhana by the consumer. Traditionally, there are many types of tarhana produced with the substitution of various ingredients in Turkey. Owing to the different cereals, legumes, dairy products, vegetables and seasoning in dough formulation, tarhana samples have a great variety of colour properties [(51)]**.** Color is one of the main properties that influences the acceptability of food. The color of tarhana samples was determined; the L*, a* and b* values are indications of lightness, redness, and yellowness, respectively.

Color results of tarhana treatments are shown in Table (5). The average L*, a*, b*, chroma, hue angle and Color index values of treatments were (68.41±0.05 to 81.07±0.05), (1.61±0.06 to 10.50±0.06), (20.84±0.05 to 34.07±0.05), (26.51±0.05 to 33.48±0.05), (1.43±0.05 to 4.76±0.05) and (00 to 36.30±0.05), respectively. According to the results, quinoa flour added tarhana treatments gave higher L* (lightness) and hue angle values and lower redness, yellowness and chroma values than the other replacer flours added tarhana formulations. Brightness (L*) values of tarhana treatments declined after the high quinoa flour addition 100%. WQF Chickpeas flour added treatments showed the highest redness, yellowness and chroma values while the quinoa flour added tarhana treatments showed the lowest. It was determined that as the usage level of the chickpeas flours increased 100% CHF, the lightness value decreased. In contrast to this, when the usage level of the quinoa flours increased, the lightness value increased. When L* value of control was examined, it was seen that the L* values of wheat flour were higher than those of quinoa and chickpeas flours. For this reason, it was thought that decreasing the wheat flour ratio causes a decrease of the L* value. As expected, WQF and CHF affected the color of tarhana samples. Its reason could be due to colour intensity of the raw material, browning reaction, and high phytic acid content. Bilgiçli [(26)] reported phytic acid degraded during the fermentation of tarhana, so free mineral content of tarhana increased. Then, these the free minerals catalyzed some non-enzymatic browning reactions. Valencia-Chamorro **[52]** reported that phytic acid is located in the external layers as well as in the endosperm and the average phytic acid concentration was 1.18 g/100 g in varieties of quinoa

Table (5): Color values, Chroma, Hue angle and colour index of tarhana powder.

Treatments	L*	a*	b*	Chroma	Hue angle	Color index
Control	81.07±0.05^{f}	6.11±0.06^{c}	31.17±0.05^{c}	28.18±0.05^{c}	1.43±0.05^{a}	.00^{a}
T1	78.24±0.05^{d}	1.61±0.06^{a}	20.84±0.05^{a}	26.51±0.05^{a}	2.28±0.05^{b}	41.25±0.05^{f}
T2	79.04±0.05^{e}	4.20±0.06^{b}	26.83±0.05^{b}	26.93±0.05^{b}	2.19±0.05^{b}	36.30±0.05^{e}
T3	74.30±0.05^{c}	8.59±0.35^{d}	33.22±0.05^{d}	30.31±0.05^{e}	4.15±0.05^{d}	32.36±0.05^{b}
T4	70.15±0.05^{b}	10.50±0.06^{e}	34.50±0.05^{f}	33.48±0.05^{f}	4.76±0.05^{e}	35.55±0.05^{d}
T5	68.41±0.05^{a}	10.36±0.06^{e}	34.07±0.05^{e}	28.59±0.05^{d}	3.86±0.05^{c}	33.64±0.05c

Data are presented as means ± SDM (n=3). a, b, c, d, e and f: Means with different letters among treatments in the same column are significantly different ($p \leq 0.05$). Control: Wheat flour (WF) (72%), T1: white quinoa flour (WQF) (100%), T2: chickpeas flour (CHF) (100%), T3: 50% WF + 50% CHF, T4: 50% WF + 50% WQF and T5: 50% WF +25% CHF +25% WQF

Functional properties of tarhana

Determination of the Functional properties of tarhana is of great importance for the processing and manufacturing of the product. Ingredients of tarhana affect the functional properties of the final product [53]. Ertaş *et al.* [54] reported that water absorption capacity had crucial effects on the functional properties of viscous foods. Functional properties of tarhana treatments are presented in Table (6). WAC represents the ability of a product to associate with water under conditions where water is limiting **[55]**. Substitution of wheat flour (72%) with different ratios of CHF and WQF have significantly ($p \leq 0.05$) increased water and oil absorption capacity of tarhana product (from 58.76% for wheat flour to 65.89% for the 100% chickpea flour and 61.40 % for the 100% quinoa flour)**,** High OAC is due to the presence of a large proportion of hydrophobic groups as compared with the hydrophilic groups on the surface of protein molecules [56].

Water absorption increased with an increasing amount of chickpea flour added. A similar result was also reported by Dodok *et al*. [57] who reported that replacement of wheat flour by 20 % chickpea flour increased water absorption by about 2 %. Also, Sudha *et al*. [58] showed quinoa flour water absorption of 141.5± 0.54% that is significantly higher than that of wheat flour (76.3%).Water absorption is a function of protein in viscous foods such as soups, dough and baked products; hence, quinoa flour may be good in these food formulations. The oil absorption capacity of quinoa flour (46%) was lower than those of soy flour (84.4%) and wheat flour (84.2%) **[59]**. Oil absorption is paramount since oil serves as a flavor retainer and increases the mouth feel of foods **[60]**.

Replacing tarhana with CHF and WQF significantly increased ($p < 0.05$) the foaming capacity and stability of the final tarhana. 100% CHF treatment achieved the highest value of foaming capacity and stability (56.46±0.05 and 97.02±1.4) respectively than wheat flour tarhana, Jagannadham *et al*. [61] noticed a higher foaming capacity and the foaming stability in chickpea flour than wheat flour. This result is confirmed with Yadav *et al*. [62] who stated that foaming stability of chickpea flour was 97.5% and refined wheat flour was 95.7%. Food ingredients with good foaming capacity and stability can be used in bakery products **[63]**.while T4 (50% WF + 50% WQF) was the lowest values (50.54±0.05 and 92.61±1.7) respectively. Bolontrade *et al*. [64] reported that the foams prepared at acidic pH were stable than the alkaline pH and also reported that soluble fractions of protein showed greater stability than the total protein.

Emulsification activity results showed that significantly increased ($p \leq 0.05$) when substitution of wheat flour (72%) with different ratios of with CHF and WQF. 100% CHF and 100%WQF treatment achieved the highest value of emulsification activity than wheat flour tarhana. Chickpea starch and proteins exhibit good emulsifying, foaming and pasting properties [65].

Table (6): Functional properties of tarhana treatments

Treatments	WAC (%)	OAC (%)	FC (%)	FS	EA (%)
Control	58.76±0.05[b]	10.67±0.05[b]	43.07±0.05[a]	92.74±1.6[a]	57.39±0.05[a]
T1	61.40±0.05[d]	11.58±0.05[d]	51.28±0.05[c]	93.56±1.5[ab]	67.96±0.05[e]
T2	65.89±0.05[f]	14.16±0.05[f]	56.46±0.05[e]	97.02±1.4[c]	70.54±0.05[f]
T3	62.56±0. 29[e]	12.52±0.05[e]	53.15±0.05[d]	96.38±1.7[bc]	67.29±0.05[d]
T4	60.50±0.05[c]	10.80±0.05[c]	50.54±0.05[b]	92.61±1.7[a]	63.95±0.05[b]
T5	58.40±0.05[a]	9.68±0.05[a]	51.50±0.34[c]	94.85±1.2[bc]	65.78±0.05[c]

Data are presented as means ± SDM (n=3). a, b, c, d, e and f: Means with different letters among treatments in the same column are significantly different ($p \leq 0.05$). Control: Wheat flour (WF) (72%), T1: white quinoa flour (WQF) (100%), T2: chickpeas flour (CHF) (100%), T3: 50% WF + 50% CHF, T4: 50% WF + 50% WQF and T5: 50% WF +25% CHF +25% WQF

Sensory properties of tarhana soup

Results of sensory properties of tarhana samples Table (7) showed that, substitution of wheat flour 72% with 100% chickpeas flour has improved the taste of traditional tarhana and scored the highest value superior to the control sample. Concerning the color, tarhana soup samples supplemented with 100% quinoa flour and T5 (50% WF +25% CHF +25% WQF) were the most liked samples scoring 8.50 and 8.06, respectively. Control soup recorded the highest flavor score of 8.66. The tarhana soups containing 50% WF + 50% CHF addition level had the highest scores for consistency. Concerning sourness, the addition of WQF 100% increased sourness. Tarhana soup with 100% CHF had the highest score in overall acceptability than all treatments. The overall sensory analysis results indicated that, utilization of whole cereal grains meal in tarhana production resulted in acceptable soup properties concerning most of the sensory properties.

QF affected the scores of sensory properties of gluten-free tarhana soups. Tarhana soups prepared with 50% QF gave the highest scores for consistency and overall acceptability [66].

According to sensorial analysis, 20% quinoa flour added tarhana samples gave the highest scores from panelists according to taste, flavor, sourness and general likes [(67)].

Table (7): Sensory properties scores of tarhana soup samples

Treatments	Taste	Color	Flavor	Consistency	Sourness	Overall acceptability
Control	8.00 ± 1.00^{d}	$8.06\pm.40^{d}$	$8.66\pm.28^{e}$	$8.83\pm.28^{f}$	$6.56\pm.98^{b}$	$8.73\pm.46^{f}$
T1	$7.23\pm.25^{c}$	8.50 ± 0.5^{e}	6.06±.11a	$6.56\pm.51^{a}$	$7.50\pm.50^{f}$	$7.00\pm.50^{c}$
T2	$8.33\pm.28^{e}$	5.96 ± 0.25^{a}	7.73±.25d	$7.40\pm.36^{d}$	$6.33\pm.28^{a}$	$8.33\pm.28^{e}$
T3	$7.23\pm.25^{c}$	6.50 ± 0.50^{c}	7.23±.25c	$7.06\pm.11^{b}$	$7.40\pm.36^{e}$	$6.33\pm.28^{a}$
T4	$6.23\pm.25^{a}$	$6.23\pm.25^{b}$	$7.00\pm.5^{b}$	$7.66\pm.28^{e}$	$6.90\pm.36^{c}$	$7.73\pm.25^{d}$
T5	$6.93\pm.40^{b}$	8.06 ± 0.11^{d}	$7.23\pm.25^{c}$	$7.33\pm.28^{c}$	$7.00\pm.50^{d}$	$6.66\pm.28^{b}$

Data are presented as means ± SDM (n=10). a, b, c, d, e and f: Means with different letters among treatments in the same column are significantly different ($p\leq0.05$).Control: Wheat flour (WF) (72%), T1: white quinoa flour (WQF) (100%), T2: chickpeas flour (CHF) (100%), T3: 50% WF + 50% CHF, T4: 50% WF + 50% WQF and T5: 50% WF +25% CHF +25% WQF

Fig. (2). Color of tarhana powder prepared from various ingredients

Conclusion

In our research, the use of legumes and pseudo-cereals affected each of the chemical and functional properties of tarhana treatments significantly. Our findings showed that the use of CHF (legume flours) and WQF (pseudocereals) improved the chemical properties of tarhana when compared to the use of WH (cereal flours). Using CHF and WQF improved the functional properties such as foaming capacity, water absorption capacity and emulsifying activity. Since tarhana is a food product, of course its sensorial properties are very important from the standpoint of consumer acceptability. When we evaluate the results obtained from sensory analyses, the remarkable finding in this study that the use of CHF (100%) and WQF (50%) in tarhana production improved the overall acceptability scores of tarhana treatments.

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